Lesson Plan: **Size of an Atom / Powers of Ten**
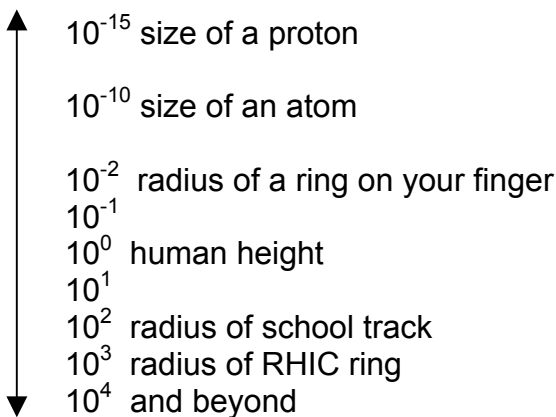
Create a pictorial diagram of relative sizes of objects in our universe as powers of 10

10^{-15} size of a proton

10^{-10} size of an atom

10^{-2} radius of a ring on your finger
10^{-1}
10^{0} human height
10^{1}
10^{2} radius of school track
10^{3} radius of RHIC ring
10^{4} and beyond

Objectives:

Students will be able to compare sizes of different objects.
Students will understand how scientific notation can be useful to represent magnitude.

Background and Questions: (This part needs to be cleaned up and re-structured)

Imagine yourself leaning back in a comfortable chair. Your head is approximately 3 feet off the floor (that's about 1 meter of height). In scientific notation that's 1×10^{0} m . Now imagine standing to view the world from about 6 feet of height (~ 2 meters).

1. Represent this new height in scientific notation.
2. _____meters

Solution for teacher: 2×10^{0} m

Notice that doubling the height does not change the exponent on the ten. The exponent is called the ***power of ten*** or ***order of magnitude*** of the number. The relationship between consecutive orders of magnitude is a multiple of ten. The next order of magnitude is 10^{1} (10 m), then 10^{2} (100 meters).

Think of the 100-meter sprint on the track. On a 400 meter track the distance across the oval is approximately 100 m. It would take 2.5 laps around to reach the next order of magnitude, 10^{3} meters (1000 meters) and 25 laps to get to the next order of magnitude 10^{4} or 10,000 meters.

The RHIC ring at BNL where gold nuclei are accelerated to nearly the speed of light is a little less than 10^{3} meters in radius giving it a circumference of about 2.4 miles. It can be seen in the satellite image shown below.

2. Compare the RHIC ring to the ring on your finger. The radius of a beautiful gold ring on your finger is approximately 1 cm or 10^{-2} meter. How many times bigger, in powers of ten, is the RHIC.

Solution for teacher:

The ratio of bigger to smaller is $10^3/10^{-2} = 10^5$
or 100,000 times bigger

3. How big is the RHIC ring compared to the school track?

$10^3/ 10^2 = 10^1$ or 10 x bigger

4. Now, use the chart above to compare the size of an atom to the golden ring for your finger. How many times smaller is the atom?

The ratio of bigger to smaller is $10^{-2}/10^{-10} = 10^8$
or 100 million times smaller!

5. Continue to zoom in on the nucleus. How big is a proton in the nucleus compared to the atom itself ?

$10^{-10}/10^{-15} = 10^5$ or 100,000 smaller

Look back to #2, Imagine enlarging an atom to the size of the RHIC accelerator ring. A proton in the nucleus of this overgrown atom would be the size of the ring on your finger!

To get a better picture of the relative size of the nucleus compared to the atom itself, try one more challenge…

6. If an atom were the size of the earth, find the radius in meters of the super-sized proton within its nucleus. Compare your answer to a distance from your school to a location people are familiar with.

Supplements to this exercise:
      Fermi questions
      Powers of Ten Book
      Powers of Ten Video
      Cosmic Voyage IMAX Video